FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
216268US	09/926607

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SE00/01068	25 May 2000	27 May 1999

TITLE OF INVENTION

AXIAL REVERSED COOLING OF A ROTOR AND A COIL END SECTION IN AN ELECTRICAL ROTATING MACHINE

APPLICANT(S) FOR DO/EO/US

Nils-Ivar LANDGREN

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Notice of Priority
Request for Consideration of Documents Cited in the International Search Report

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/926607	PCT/SE00/01068	216268US

24. The following fees are submitted:.		CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :			
☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1040.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$890.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$740.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$710.00**		
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ENTER APPROPRIATE BASIC FEE AMOUNT =		**$1,040.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		**$130.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	17 - 20 =	0	x $18.00	**$0.00**	
Independent claims	3 - 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,170.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$1,170.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	**$0.00**	
TOTAL NATIONAL FEE =				**$1,170.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	**$0.00**	
TOTAL FEES ENCLOSED =				**$1,170.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$1,170.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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Nov. 26 2001
DATE

216268US-6X PCT
ENKEL 8627

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

NILS-IVAR LANDGREN : ATTN: APPLICATION DIVISION

SERIAL NO: NEW U.S. APPLICATION
(Based on PCT/SE00/01068)

FILED: HEREWITH

FOR: AXIAL REVERSED COOLING OF A ROTOR AND A COIL END SECTION IN AN ELECTRICAL ROTATING MACHINE

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

Prior to examination on the merits, please amend the above-identified application as follows:

IN THE CLAIMS

Please cancel Claims 1-16.

Please add new Claims 17-33 as follows:

17. (New) A method for air-cooling a high voltage rotating electric machine having a rotor with an axial side, an opposite axial side, axial duct and an other axial duct, a stator having a coil-end section, and a winding disposed in the stator, comprising:

passing a cooling air from an air-cooling source through the coil-end section of the stator;

passing the cooling air through an air gap between the axial side of the rotor and the stator;

guiding the cooling air through the axial rotor duct to a center of the rotor;

reversing a direction of the cooling air;

passing the cooling air out of an other axial rotor duct to the air-cooling source; and

recooling the cooling air.

18. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising a step of:

guiding a predetermined portion of the cooling air passing through the coil-end section of the stator to an end of the rotor.

19. (New) A method for air-cooling a high voltage rotating electric machine according to claim 18, wherein:

the predetermined portion is 30%.

20. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising a step of:

rotating the cooling air entering the coil-end section of the stator, so as to create at least one of a vortex of air and a turbulence of air in the coil-end section of the stator.

21. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising a step of:

guiding the cooling air in the coil-end section of the stator with a screen.

22. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising a step of:

separating the cooling air exiting the rotor from the cooling air in the coil-end section of the stator.

23. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising a step of:

pressurizing the cooling air exiting the rotor with a fan and a diffuser.

24. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, further comprising:

applying all steps to the opposite axial side of the rotor.

25. (New) A method for air-cooling a high voltage rotating electric machine according to claim 17, wherein:

the winding is comprised of a cable having a flexible electric conductor with a casing configured to contain an electric field formed around the flexible electric conductor.

26. (New) A high voltage rotating electric machine, comprising:

a stator with a first coil end section and a second coil end section;

a stator winding; and

a rotor having a rotor center, with field windings surrounded by a plurality of ducts, and configured to be cooled by air flowing axially through the plurality of ducts,

wherein said high voltage rotating electric machine is configured to be cooled with a circulation of cooling air passed from a cooling unit through the coil end section to an air gap between the stator and the rotor to the rotor center via the plurality of ducts, and back to the cooling unit.

27. (New) A high voltage rotating electric machine according to claim 26, further comprising:

a fan connected to the rotor; and

a diffuser connected to the fan.

28. (New) A high voltage rotating electric machine according to claim 26, wherein:

said high voltage rotating electric machine is configured so that a cooling airflow is axially forced into the air gap toward the rotor center from the first coil end section of the stator and the second coil end section of the stator.

29. (New) A high voltage rotating electric machine according to claim 26, wherein:

the stator winding is comprised of a high voltage cable having a flexible electric conductor with a casing configured to contain an electric field formed around the flexible electric conductor.

30. (New) A high voltage rotating electric machine according to claim 29, wherein:

the casing comprises an insulation system having an inner semiconductor layer disposed on the flexible electric conductor, a solid insulation layer disposed on the inner semiconductor layer, and an outer semiconductor layer disposed on the solid insulation layer, wherein the outer semiconductor layer is configured to have an electric conductivity higher than the solid insulation layer and is connected to a node having at least one of a ground potential and a low voltage potential so as to contain the electric field formed around the flexible electric conductor.

31. (New) A high voltage rotating electric machine according to claim 30, wherein:

the inner semiconducting layer is configured to have an electric conductivity lower than the flexible electric conductor and to substantially equalize an electric field formed on an outer surface of the inner semiconducting layer.

32. (New) A high voltage rotating electric machine according to claim 30, wherein:

the solid insulation layer is comprised of a polymer.

33. (New) A high voltage rotating electric machine, comprising:

a winding of a cable with a flexible electric conductor and an insulation having two semiconductor layers and a solid insulation layer;

means for cooling said machine; and

means for containing an electric field formed around the flexible electric conductor.

REMARKS

Favorable consideration of this Application as presently amended is respectfully requested.

Claims 17-33 are active in the present Application; Claims 1-16 having been canceled and Claims 17-33 added by way of the present Preliminary Amendment. The new claims have been drafted in a manner consistent with U.S. practice. It is therefore believed that no issues of new matter have been raised.

The present document is one of a set of patent applications containing related technology as was discussed in "response to petition under 37 C.F.R. §1.182 seeking special treatment relating to an electronic search tool, and decision on petition under 37 C.F.R. §1.183 seeking waiver of requirements under 37 C.F.R. §1.98," filed in the holding application (U.S. Patent Application No. 09/147,325). Consistent with this decision, a copy of the decision is filed herewith. Also, an Information Disclosure Statement is filed herewith including a PTO Form 1449 with references that are included as part of the specially-created official digest in class 174. It is believed that submission of these materials and the reference to the holding application (Serial No. 09/147,325) is sufficient for the present Examiner to consider the references in the holding application, consistent with the decision.

Accordingly, examination on the merits of Claims 17-33 is believed to be in order, and an early and favorable action is respectfully requested.

Respectfully submitted,

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Marked-Up Copy
Serial No:

Amendment Filed on:
11-26-2001

IN THE CLAIMS

Please cancel Claims 1-16.

Please add new Claims 17-33

AXIAL REVERSED COOLING OF A ROTOR AND A COIL END SECTION IN AN ELECTRICAL ROTATING MACHINE

Technical field

The present invention relates to rotating electric machines such as synchronous machines, normal asynchronous machines as well as duel-fed machines, applications in asynchronous static current converter cascades, outerpole machines and synchronous flow machines as well as alternating current machines intended in the first place as generators in a power station for generating electric power. The invention relates particularly to the cooling of rotors in turbo applications of such machines having an axial airflow through the axial ducts of the rotor thereby cooling the insulated electric conductors that constitute the rotor winding and indirectly also the rotor poles.

Background art

The invention is based on systems, in which the stator cooling circuit is separated from the rotor cooling circuit, such as when the stator is water-cooled. The air must have a certain velocity and a certain volume flow in the ducts so as to obtain sufficient cooling of the rotor and the field winding inclusively, in order to air-cool the rotor in an electric machine in which the rotor is provided with air ducts. It is hereby desirable to achieve sufficient air speed (m/s) as well as sufficient air volume (m^3/s) in the ducts of the rotor with the least possible ventilation losses. The ventilation losses arise partly as a result of air gap friction and partly as a result of a component, which is proportional to the total air volume blown into the ducts of the rotor. The flow volume should therefore be as small as possible in order to minimise the ventilation losses.

In the case of combined air cooling of both the stator and the rotor it is usually the permissible rise in the air temperature that determines the airflow. Not much can be done about solving the problem of minimising ventilation losses since the rise in temperature is only dependent on the total power losses and the airflow; the airflow being unequivocally determined by losses and permissible rise in temperature.

The airflow may be minimised if the stator is water-cooled instead because the air does not need to transport as much heat effect away from the generator.

Besides, when only the rotor is air-cooled, it is the coefficient of heat transfer at the field windings, which is dimensioned, and not the rise in temperature. The coefficient of heat transfer rises when the air speed rises. Thus, by forcing the air to pass close to the field windings the necessary airflow required can be reduced.

Furthermore, cooling of the coil end parts, located axially at both ends of the stator, is required. One of the main problems for cooling this section, after the airflow has passed the rotor, is that the coil end section tends to be unsatisfactorily cooled.

In conventional cooling systems both cooling of the rotor and cooling of the stator is almost always combined so that the air also passes the radial cooling ducts of the stator after having passed the rotor. This can give rise to high air temperatures where the air from the rotor comes into contact with the stator. This is partly dependent on air from the rotor absorbing heat losses in the rotor and the field winding inclusively, and partly dependent on the whole rotational effect of the air being transformed into heat in the rotor and the air gap.

Similar machines have conventionally been designed for voltages in the range 15 - 30 kV whereby 30 kV has normally been considered to be an upper limit. In the case of generators this means that a generator must be connected to the power network via a transformer which steps up the voltage to the level of the power network which lies in the range of approximately 130 - 400 kV. The present invention is intended for use with high voltages. High voltages shall be understood here to mean electric voltages in excess of 10 kV. A typical operating range for a rotating electric machine comprising an air-cooled rotor, according to the invention, may be voltages from 36 kV up to 800 kV.

By using high-voltage insulated electric conductors in the stator of the machine, i. e, high-voltage cables, having permanent insulation of similar design to that used in cables for transmitting electric power (e.g. so-called PEX cables), the voltage of the machine can be increased to such levels that it can be connected directly to the power network without an intermediate transformer. The conventional transformer can thus be eliminated. The high-voltage cable comprises a number of strands having a circular cross section, which is made of copper (Cu). These strands are arranged in the centre of the high-voltage cable. Around the strands there is arranged a first semiconducting layer. Around the first semiconducting layer there is arranged an insulation layer, e.g. PEX-insulation. Around the insula-

tion layer there is arranged a second semiconducting layer. Reference made to high-voltage cable in the present application does thus not comprise the outer shielding means and the metal screen that normally surrounds such a cable in the distribution of energy.

Technology with one-way axial cooling in which the stator is not included in the cooling circuit is known in applications for smaller machines showing open pole gaps. Axial cooling through pole gaps, which are covered, are also known, see PCT WO98/20600.

These known types of air-cooling and water-cooling provide partially unsatisfactory cooling of especially the coil end section of a machine of the present type resulting in high ventilation losses.

Aim of the invention

The aim of the invention is to provide a method and a device for controlling the airflow in axial cooling of the rotor in order to primarily protect the cables of the stator from warm air in a rotating electric machine, especially of the type where the stator windings of the machine constitute said high voltage cables. An additional aim of the invention is to cool the coil end section with the same cooling means that cools the rotor thereby first cooling the coil end section in such a machine. The aim of the invention is to also avoid warm air from coming into contact with the stator. A further aim is to achieve a higher efficiency by reducing the ventilation losses in an air-cooled rotor. Indication of further advantageous developments of the invention follows in the description below.

Summary of the invention

The aim of the invention is fulfilled by the invention pertaining to the characteristic features given in the appended claims. The invention is based on a machine with an air-cooled rotor and water-cooled stator where the coil ends of the stator are firstly cooled through the circulation of cooling air through the coil end section and then cooled through the air gap between the stator and the rotor. Cooling first the coil end section with cooling air and thereafter the rotor implies that the most sensitive parts, which do not tolerate high temperatures, are cooled first. This is achieved by cooling air passing the coil end section first and then being led into the air gap between the stator and the rotor so that the cooling air re-

verses at the centre of the rotor, due to meeting a cooling airflow from the other side of the rotor, so as to then return through the rotor ducts within a closed cooling circuit. The reversal of the cooling airflow takes place gradually axially along the rotor so that it is completely reversed at the centre of the rotor. There are rotor fans at the centre of the rotor in order to simplify the reversal of the airflow, which rotor fans, seen from a radial section, are bevelled. The reversal of cooling air takes place gradually automatically because the cooling is completely symmetrical when the flow between the stator and the rotor from the one side of the rotor meets the flow from the other side of the rotor.

The present invention is especially suitable for a rotating electric machine having stator winding composed of high voltage cable, which with today's technique requires a temperature of 70°C.

Fundamental to the invention is that the temperature sensitive parts of the generator must be firstly cooled by cool air or other gasses. The invention is also based on the turbo generator where both the stator coil ends and the rotor are cooled by air or other gasses. The invention may also be applied solely to cooling of the rotor and applied with certain modification to hydro-generators. Air-cooling takes place in the following order: the air cooler, the stator coil ends, the air gap and lastly the rotor. The invention is especially applicable to stator winding consisting of cables having a relatively low permissible operating temperature.

From a cooling point of view, the optimal direction of the cooling airflow is reversed when compared to the conventional direction of the airflow in the cooling ducts of the rotor i.e., directed from the periphery of the rotor towards the centre of rotation. A larger driving pressure is required for this solution when compared to a conventional cooling method. The driving pressure is obtained from the one fan in combination with the one diffuser. The diffuser converts the greater part of the dynamic pressure of the air to static pressure, at the air outlet of the rotating part of the generator. This is a great advantage when compared to a conventional cooling method where the whole rotational effect of the air is transformed to heat in those sections of the generator, which are to be cooled. The reversed direction of the flow in the rotor produces higher ventilation losses of air per unit of volume compared to the conventional cooling method as a result of the necessary power produced by the fans. This depends on the ventilation losses of air per unit of volume, derived from passing through the ducts of the rotor, being partly proportional to the

speed of rotation of the air and partly proportional to the speed of rotation of the rotor or alternatively the speed of rotation of the fan at the outlet from the rotating parts of the generator. A higher periphery speed of the fans is required than of the speed of the rotor in the air gap in order to drive the air into the reverse direction through the rotor. The total ventilation losses are low despite this.

Minimisation of the volume flow is partly obtained by the temperature sensitive parts being cooled first and partly by the rotational effect of the air being converted to a driving pressure and heat after the air has left those parts which are to be cooled. The losses due to air gap friction are small because the rotational effect of the air in the air gap results in additional power at the inlet for air to the rotor instead of getting lost in heat. The ventilation losses for this ventilation principle may be further minimised by producing a smooth surface of the stator in the air gap of the stator.

There are also demands for maximum temperature on the rotor retaining ring, which keeps the rotor winding in place and which shrinks firmly to the rotor during the manufacturing process. The ventilation principle, according to the invention, surrounds the whole rotor-retaining ring with cold air. This implies both the surface of the rotor retaining ring towards the air gap and the surface towards the centre of the rotor. The warm air from the rotor is prevented from coming in contact with the rotor-retaining ring. The cold airflow from the coil end section to the rotor end also cools the rotor-retaining ring effectively.

Brief description of the drawings

The invention will now be described in more detail with reference to the accompanying drawings in which one symmetrical part of the generator is shown:

Figure 1 shows one schematic axial view of a rotating electric machine, partially in section, with an air-cooled rotor in accordance with the present invention.

Figure 2 shows a partial cross-sectional radial section A-A through the rotor according to Figure 1.

Figure 3 shows an enlarged partial view having a superposed radial section B-B according to Figure 1.

Description of the invention

Figure 1 shows a rotating electric machine 1 comprising a stator 2 with a stator winding 3, in the form of high voltage cable. The machine 1 is provided with a rotor 4, which is arranged on a machine shaft 6 that is journalled in a machine housing 5. An air gap 15 is formed between the stator 2 and the rotor 4. The rotor 4 is also provided with a radial fan 8 having blades 7, which fan increases the pressure on the cooling airflow reversing into a diffuser 18. The dynamic pressure of the airflow in the diffuser flow is converted to approx. 60 % static pressure, whereby the remaining pressure forms heat. Approximately half of the increase in pressure takes place in the fan and the remaining increase in pressure takes place in the diffuser. The airflow passes the air cooler 19 and holes, located between the cooler and the coil end section, before entering the coil end section 20. The embodiment also shows, in accordance with Figure 1, that the total airflow through the cooler 19 is 1,7 m ^{3}/s of which 0,5 m ^{3}/s (30%) cools the rotor end 21, directly after the coil end section 20, and of which1,2 m ^{3}/s (70%) flows into the air gap 15 between the stator 2 and the rotor 4. The airflow through the coil end section 20 rotates due to the outlet holes being angled such that eddy formations and turbulence are achieved. The air is alternatively guided through the coil end section with the aid of screens 16, 17.

The cooling airflow from both ends of the rotor, which is indicated by arrows in Figure 1, meets in the air gap 15, since the cooling arrangement is symmetrical. Both these cooling airflows tend to depart in the radial direction from where they meet, i.e. towards the centre of the rotor. The rotor wedges at the radial inlet for the air in a radial rotor duct 11 have been bevelled to simplify the change of direction. Figure 2 shows how such a bevelled rotor wedge 12 may be arranged where an arrow indicates how the airflow deflects radially. The airflow is deflected outwardly from the rotor 4 back into a reversed axial flow via axial rotor ducts 9. Figure 1 shows the distribution of the airflows indicated by arrows. The cooling is symmetrical around the centre line. This means cooling of the rotor in two-way axial ducts. It is hereby also evident how the coil end parts 20 allow for cooling by the airflow, before cooling of the rotor with its windings.

Figure 2 shows a partial radial section through the rotor 4, which is designed with rotor ducts 9 at both sides of each field winding 10. A rotor wedge 12 is arranged at the tops side of each field winding 10. The rotor wedge 12 is pro-

vided with a bevelled outer edge 13 to simplify the process of the airflow being deflected radially into the radial rotor ducts 11. Each radial duct 11, excluding those located beside the poles, provide two axial ducts 9 with air. In smaller entirely air-cooled machines the air gap is used to blow air through for cooling purposes in both the stator and the rotor. This is an uneconomical cooling method for larger machines, as in the present case of a water-cooled stator, and this type of air stream through the air gap should therefore be as small as possible so that it may be used where it is better needed such as in the present case for air flowing through the rotor ducts and for simultaneous cooling of the coil end parts.

Figure 3 shows by means of arrows in an axial section the reversing cooling-airflow on its way back from the rotor through the rotor ducts 9 while cooling the rotor windings at the same time. Both cooling airflows are united at the rotor end 21 once more whereby the flows are forced further through a ring-shaped duct 23. The duct 23 is formed by attaching a coaxial pipe onto a rotating rotor axial 27 via radial means of attachment 29, which are shown in a radial section in Figure 3. The circulation of cooling air is achieved by the blades 7 of the fan 8 located at the end of the pipe 25 and the fan that is attached to the rotor axial. The fan forces the cooling air further through the diffuser 18 and still further through the air cooler 19 circulating continually. Thus, the air temperature rises during the conversion of pressure in the diffuser, as described in the introduction, and then sinks back again in the air cooler. The diameter of the radial fan 8 is larger the diameter of the rotor.

The stator winding 3 of the machine is composed of a high voltage cable in the form of a flexible electric conductor having a casing capable of trapping the electric field accrued around the conductor. The casing also comprises an insulation system with an insulation made of a solid insulation material and an outer layer on the outside of the insulation having an electric conductivity higher than the insulation so that the outer layer, by being connected to earth or otherwise relatively low potential, is capable of partly functioning in a potentially equalising way and partly in principle, containing the accrued electric field on the inside of the outer layer as a result of said electric conductor. The insulation system comprises an insulation, made of a solid insulation material, and an inner layer on the inside of the insulation, at least one of the said electric conductors being arranged on the inside of the inner layer, and that the inner layer has a lower electric conductivity

than the electric conductor but sufficient for the inner layer to function in a potentially equalising way and thereby equalising with respect to the electric field on the outside of the inner layer. The solid insulation and the outer layer are made of polymer material.

5

CLAIMS

1. A method for air-cooling of the rotor and the coil end section of a stator provided with winding (3) in a rotating electric machine, **characterized** in that the cooling air passes first through the coil end section (20) and then completely or partly axially into the air gap (15) between the rotor (4) and the stator (2) so as to reverse axially at the centre of the rotor by being guided into axial rotor ducts (9) and then out through the rotor ducts whereupon the air is cooled and the circulation is then repeated.

2. A method according to claim1, **characterized** in that the cooling air is partly guided into the end section of the rotor in order to cool the field winding (10) at the end of the rotor (21).

3. A method according to any one of claims 1 - 2, **characterized** in that the cooling air is divided so that of the 100% air that flows through the coil end section (20) approximately 70% flows through the air gap/rotor ducts (15, 9) and the remaining 30% is led to the end section of the rotor in order to cool the end of the rotor (21).

4. A method according to any one of claims 1 - 3, **characterized** in that the cooling air on entering the coil end section (20) is brought to rotate such that vortex formations and turbulence in the coil end section (20) are achieved.

5. A method according to any one of claims 1 - 3, **characterized** in that the air is guided by screens (16, 17) in the coil end section (20).

6. A method according to any one of claims 1 - 5, **characterized** in that the heated cooling air from the rotor (4) is kept separate from the coil end section (20).

7. A method according to any one claims 1 -6, **characterized** in that the heated air from the rotor (4) undergoes pressure in a fan (7) and a diffuser (18) after which the air is cooled in an air cooler (19).

8. A method according to any one of claims 1 - 7, **characterized** in that the circulation of cooling air at the opposite axial side of the rotor takes place in a corresponding way, i. e., according to any one of claims 1 - 6.

9. A method according to any one of claims 1 - 8, **characterized** in that the winding (3) is composed of a cable in the form of a flexible electric conductor having a casing trapping the electric field surrounding the conductor.

10. A rotating electric machine (1) having a stator (2) provided with winding (3) and a rotor (4) provided with field windings (10) which are surrounded by rotor ducts (9), which rotor (4) is arranged to be cooled by air flowing axially through the ducts (9) of the rotor (4), **characterized** in that the rotor (4) and the coil end section (20) of the stator are arranged to be cooled by the cooling air passing through the coil end section (20) and to continue completely or partly axially into the air gap (15) between the rotor (4) and the stator (2) so as to then reverse axially at the centre of the rotor (4) by being led into the axial rotor ducts (9) and out of the rotor ducts after which the air is cooled and the circulation is then repeated.

11. A machine according to claim 10 **characterized** in that the cooling airflow is achieved by a fan (8) being connected to the rotor (4) and a diffuser (18) being connected to the fan.

12. A machine according to any one of claims 10-11, **characterized** in that the cooling airflow is arranged to be axially forced into the air gap (15) towards the centre (4) of the rotor from each coil end section (20).

13. A machine according to any one of claims 10-12, **characterized** in that the stator winding (3) is composed of a high voltage cable in the form of a flexible electric conductor having a casing capable of trapping the electric field accrued around the conductor.

14. A machine according to any one of claims 10-13, **characterized** in that the casing comprises an insulation system having an insulation made of a solid insulation material and an outer layer on the outside of the insulation having an

electric conductivity higher than the insulation so that the outer layer, by being connected to earth or other wise relatively low potential, is capable of partly functioning in a potentially equalising way and to partly, in principle, contain the accrued electric field on the inside of the outer layer as a result of said electric conductor.

15. A machine according to any one of claims 10-14, **characterized** in that the insulation system comprises an insulation made of a solid insulation material and an inner layer on the inside of the insulation, at least one of the said electric conductors being arranged on the inside of the inner layer, and that the inner layer has a lower electric conductivity than the electric conductor but sufficient for the inner layer to function in a potentially equalising way and thereby equalising with respect to the electric field on the outside of the inner layer.

16. A machine according to any one of claims 10-15, **characterized** in that the solid insulation and the outer layer are made of polymer material.

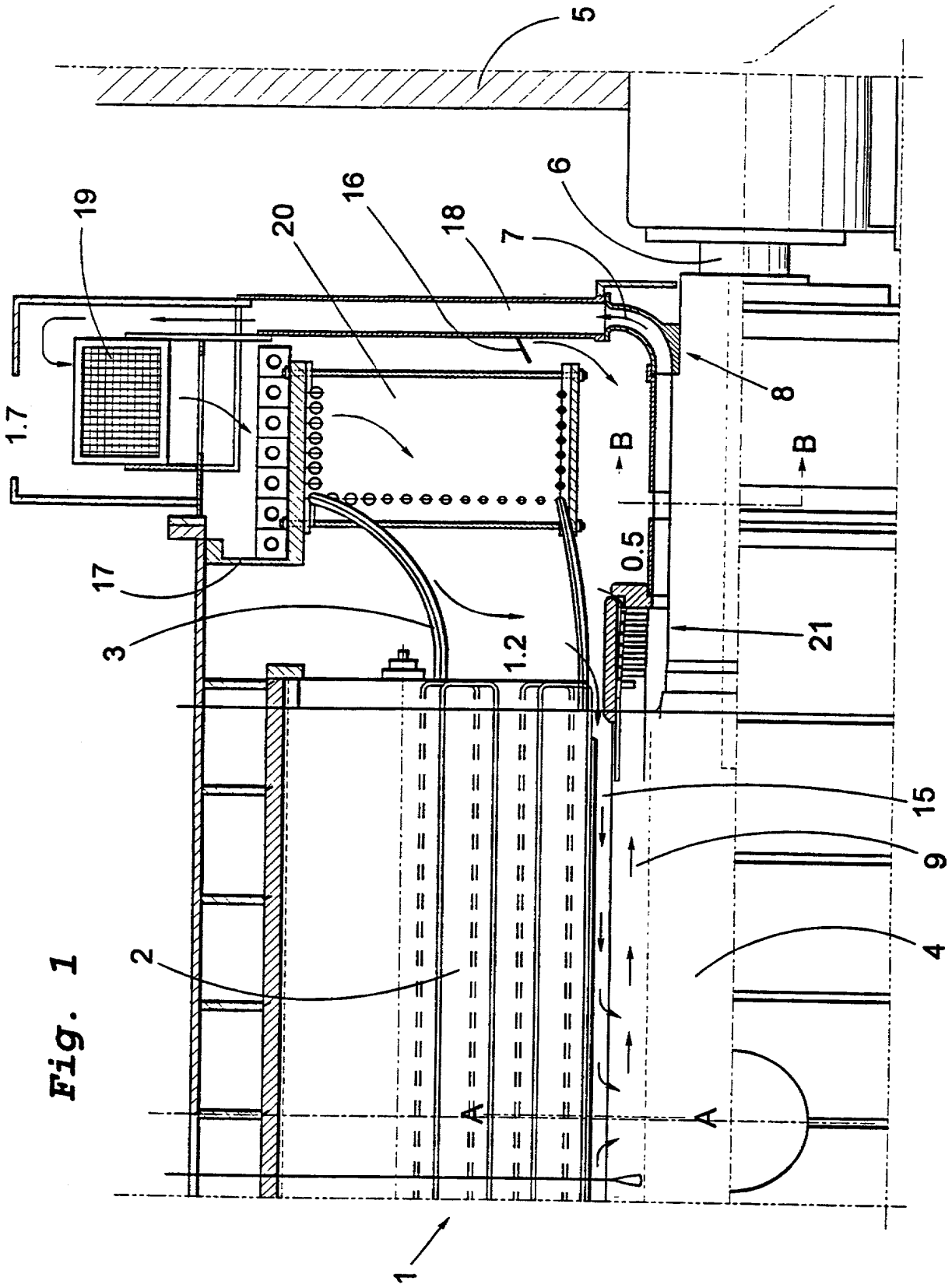

Fig. 1

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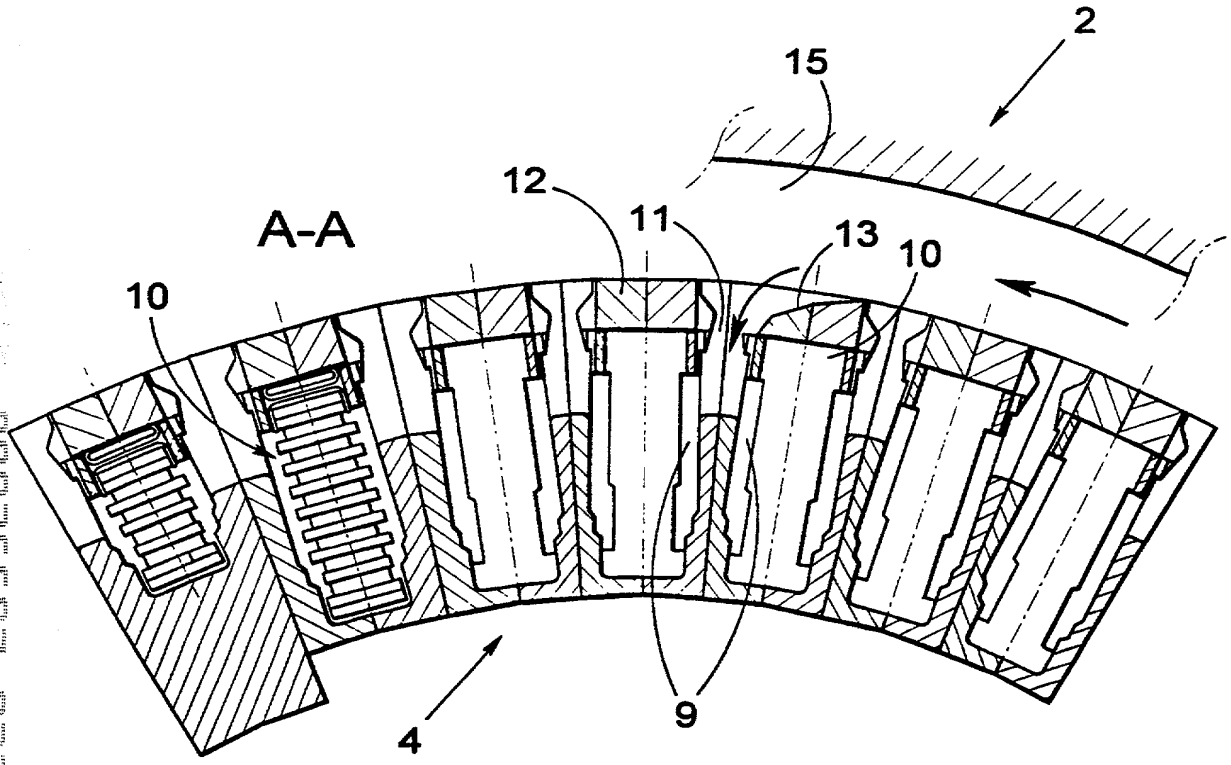

Fig. 2

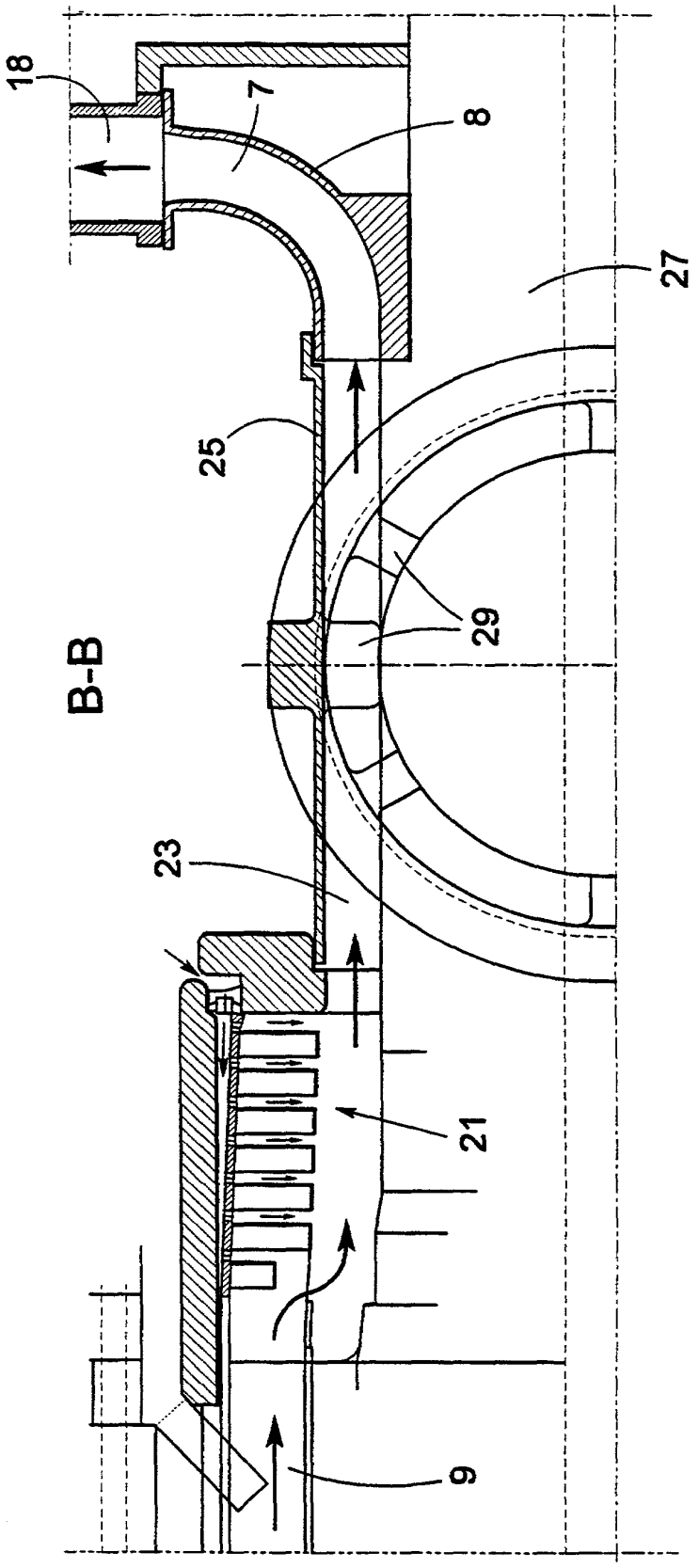

Fig. 3

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Declaration and Power of Attorney for Patent Application
Declaración y poder para solicitud de patente
Spanish Language Declaration

Como inventor abajo nombrado, por este medio declaro que :

As a below named inventor, I hereby declare that:

Mi residencia, dirección postal y cuidadanía son los que indican a continuacón, al lado de mi nombre.

My residence, mailing address and citizenship are as stated next to my name.

Considero que soy el primer, original y único inventor (si hay un solo nombre indicado a continuación) o el primer, original y único inventor conjunto (en caso de múltiples nombres a continuación) de la materia objeto de la reivindicación y para la cual se solicita una patente sobre el invento titulado

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

AXIAL REVERSED COOLING OF A ROTOR AND A COIL END SECTION IN AN ELECTRICAL ROTATING MACHINE

cuya descripción se anexa a la presente, salvo

the specification of which

☐ adjunto en el presente

☐ is attached hereto.

☒ fue presentada el November 26, 2001

☒ was filed on November 26, 2001

bajo el número de solicitud de Estados Unidos o número de solicitud internacional PCT

as United States Application Number or PCT International Application Number

_____ y modificada el día

09/926,607 and was amended on

_____ (de ser procendente)

_____ (if applicable)

Por este medio declaro que ha revisado y que entiendo el contenido de la descripción que antecede, incluso las reivindicaciones, según estén modificadas de acuerdo con cualquier modificación arriba citada.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Por este medio reconozco mi deber de divulgar información que sea esencial con respecto a la patentabilidad según se define en el Titulo 37 del Código de Regulaciones Federales § 1.56.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

Spanish Language Declaration

Por este medio reclamo prioridad extranjera bajo el Título 35, Código de Estados Unidos, § 119(a)-(d) o § 365(b) de cualquier o cualesquier solicitud(es) de patente o certificado de inventor extranjera(s), o bajo el Título 35, § 365(a) del mismo Código, de cualquier solicitud internacional PCT en que se designa por lo menos un país distinto a los Estados Unidos, dicha(s) solicitud(es) o dicho(s) certificado(s) enumerándose a continuación, y, marcando la(s) siguiente(s) casilla(s), también he identificado cualquier solicitud de patente o de certificado de inventor extranjera que tenga una fecha de presentación anterior a la fecha de la solicitud sobre la cual se reclama prioridad.

I hereby claim foreign priority under Title 35, United States Code, § 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
Solicitud(es) Extranjera(s) Anterior(es)

(Number) (Número)	(Country) (País)	(Day/Month/Year Filed) (Día/Mes/Año de presentación)	Priority Claimed Derecho de Prioridad reivindicado ☒ Yes / Sí	☐ No / No
9901928-3	Sweden	27 May 1999		

Por esto medio reclamo el beneficio bajo el Título 35, Código de Estados Unidos, §119(e) de cualquier o cualesquier solicitud(es) provisional(es) de Estados Unidos enumerada(s) a continuación.

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(Application No.) (de solicitud)	(Filing Date) (Fecha de presentación)

(Application No.) (de solicitud)	(Filing Date) (Fecha de presentación)

Por este medio reclamo el beneficio bajo el Título 35, Código de Estados Unidos, § 120 de cualquier o cualesquier solicitud(es) de Estados Unidos o, bajo el Título 35, § 365(c) del mismo Código, de cualquier solicitud internacional PCT en que se designan los Estados Unidos, dicha(s) solicitud(es) enumerándose a continuación y, en la medida en que el objeto de cada una de las reivindicaciones de la presente solicitud no hubiere sido divulgado en la solicitud anterior de Estados Unidos o internacional PCT, según lo dispuesto en el primer párrafo del Título 35, Código de Estados Unidos, § 112, reconozco el deber de divulgar información que fuere esencial con respecto a la patentabilidad, según se define en el Título 37, Código de Regulaciones Federales, § 1.56, que hubiere llegado a estar disponible entre la fecha de presentación de la solicitud anterior y la fecha de presentación nacional o internacional PCT de la presente solicitud.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.) (de solicitud)	(Filing Date) (Fecha de presentación)	(Status: Patented, Pending, Abandoned) (Estado: patentado, en trámite, abandonado)
PCT/SE00/01068	May 25, 2000	

(Application No.) (de solicitud)	(Filing Date) (Fecha de presentación)	(Status: Patented, Pending, Abandoned) (Estado: patentado, en trámite, abandonado)

Por este medio manifesto que todas las declaraciones hechas en la presente en base a mis propios conocimientos son verdaderas y que considero que son verdaderas todas las declaraciones hechas en base al mejor saber y entender; adicionalmente manifesto que dichas declaraciones se hicieron con conocimiento de que las declaraciones falsas intencionales y similares son punibles por multa o encarcelamiento o ambos, bajo la Sección 1001 detl Título 18 del Código de Estados Unidos y que dichas declaraciones falses intencionales pueden poner en peligro la validez de la solicitud o de cualquier patente concedida en vitud de la misma.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Spanish Language Declaration

PODER : Como inventor nombrado, por este medio designo al siguiente abogado o abogados y/o agente o agentes para que tramiten la presente solicitud y realicen todas las gestiones ante la Oficina de Patentes y Marcas Registradas en relación con la misma: (*Indique el nombre y número de registro).*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)

022850

Envíe la correspondencia a:

Send Correspondence to:

022850

Dirija las llamadas telefónicas a: (*nombre y número de teléfono*)

Direct Telephone calls to: (name and telephone number)

(703) 413-3000

Nombre completo del único o primer inventor 1 – 00	Full name of sole or first inventor Nils-Ivar LANDGREN
Firma del inventor Fecha	Inventor's signature Date 2002-02-07
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